SCIENCE

VOL. 79 FRIDAY, FEBRUARY 9, 1934 No. 2041

SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. MCKEEN CATTELL and published every Friday by

THE SCIENCE PRESS

New York City: Grand Central Terminal

Lancaster, Pa. Garrison, N. Y.

Annual Subscription, $6.00 Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary, in the Smithsonian Institution Building, Washington, D. C.

ON POISONS AND DISEASE AND SOME EXPERIMENTS WITH THE TOXIN OF THE BACILLUS TETANI.[1]

By Dr. JOHN J. ABEL

EMERITUS PROFESSOR OF PHARMACOLOGY AND DIRECTOR OF THE LABORATORY FOR ENDOCRINE RESEARCH, THE JOHNS HOPKINS UNIVERSITY

II

EXPERIMENTS WITH THE TOXIN OF THE BACILLUS TETANI[2]

I MAY now be permitted to give a brief account of some experiments with the causative principles of the disease known as tetanus or lockjaw, a truly frightful disease of the central nervous system terminating in exhausting and fatal convulsions. It is fortunately one of the rarer diseases of man, but in time of war and on certain occasions, such as Fourth of July celebrations, it occurs more frequently. It has long afflicted the race, and historians of medicine find it described in the Hippocratic writings and other early sources of medical knowledge. Of all our domestic animals, the horse is more subject to it than we, and the loss of these animals from tetanus, more especially in tropical countries, is considerable.

Until 1884 the cause and true nature of the disease remained unknown. In that year two Italian investigators demonstrated the transmissibility of the disease to animals by injecting them with a little purulent material from a small lesion of an individual with a fatal attack of tetanus. In the years 1884–1890, bacteriologists definitely established the infective nature of the disease by isolating the causative organism in pure culture. One ordinarily speaks of this organism as the bacillus tetani, but it is known to the specialist as clostridium tetani, one of the family of

[1] Address of the president of the American Association for the Advancement of Science, Boston, December 27, 1933.

[2] This part of the address was not presented in its entirety.

the bacillaceae of the general class of plant organisms known as Schizomycetes.

My associates, Dr. B. Hampil, of the Department of Bacteriology of the School of Hygiene and Public Health of the Johns Hopkins University, Professors F. C. Lee and W. M. Firor, of the surgical department of the Johns Hopkins Medical School, Mr. E. A. Evans, Jr., and I have been occupied for more than a year with experiments relating to certain aspects of this disease.

As there is only time for a very concise presentation, I shall summarize the main characteristics of the disease and the results of our own experiments and those of others in the following pages.

(1) That the disease may appear, the bacillus tetani or its spores must be introduced beneath the skin. Here the bacillus readily multiplies, if it meets with the proper conditions for its growth, such as association with relatively harmless pus-forming organisms as is generally the case, and a diminished tension of oxygen, or a necrosis of cells when spores only are introduced. The bacilli are not disposed throughout the body but continue to multiply for a time at the site of inoculation. Only very rarely and under special circumstances are they or their spores found elsewhere in the body.

(2) During the time of bacillary growth in the infected area a highly poisonous substance called tetanus toxin appears. This exceedingly potent, water-soluble substance is now known to be the true cause of the disease. A few bacteriologists believe that the bacillus does not itself produce a toxin, but rather a relatively harmless pro-toxin, which is transformed into the deadly toxin in culture media or at the site of infection in the presence of albumose-like substances. Nothing whatever is known of the chemical nature of the toxin. It is being constantly removed from its place of origin by lymphatic vessels and by the blood capillaries and is then distributed throughout the body by the arterial current. A boy with "lockjaw" is as truly poisoned as if he had been bitten by a rattlesnake.

(3) It is thought that this toxin of entirely unknown character finally reaches certain cells of the spinal cord and brain and by an action on them induces generalized convulsions of the most violent nature. The disease is now generally defined as clearly and solely one of the central nervous system. Certain of its symptoms, however, as the so-called local tetanus and the long-continued rigid states of certain muscles, lasting for weeks or months, that are occasionally observed in man, can not be brought into line with this concise definition of the disease. I can not enter here into a more detailed and accurate description of the course and extent of the alterations that finally affect the nervous and muscular systems.

(4) Our toxin, which is known only by its action in the animal organism, and this is true also of many other principles of its class, is of an exceedingly great potency, excelled only by the botulinus toxin found in meats and canned vegetables infected with the botulinus bacillus (Botulus—a sausage). It has been found that crude precipitates of the tetanus toxin will kill a mouse weighing 15 grams in the minute quantity of 0.00000005 gram. I think it more than likely that such precipitates contain only about 10 per cent., or even less, of the poison. Assuming the sensitivity of man to be equal to that of the monkey, which again is about equal to that of the highly sensitive horse, I may hazard the calculation that it would require only 0.01 mgm of the really pure poison to kill a man weighing 150 pounds, on the supposition that my calculations have any factual basis.

(5) During the entire time the toxin is being absorbed from its place of production, and often for some days following the cessation of its production, or after the excision of the infected organ as in animal experiments, there is observed a so-called period of incubation, that is to say, a time during which there are no observable signs of illness. This time of incubation varies in human beings and in such very susceptible animals as the horse from a few to many days. When this period of incubation in human beings is not more than five or six days, the mortality is nearly 90 per cent.; when it is longer, say 10 days or many more, the mortality is still about 50 per cent. The period of incubation in the very susceptible animals is considerably reduced when larger doses of the toxin are injected into them or when, in the natural disease, a very large amount of the poison is produced in the original lesion. It is never in any case, except after the intravenous injection of immense doses, reduced to less than three to four days. In the relatively insusceptible rabbit, in which the period is about 18 hours, it can be shortened by a few hours only with enormously large doses of the toxin. French observers have found that the subcutaneous injection of thirty thousand minimal lethal doses shortened the period of incubation by four hours, while the enormous dose of ninety thousand fatal doses shortened it by two hours only. Long periods of incubation are not confined to the infectious diseases. Pharmacological literature contains many examples of this phenomenon after the injection of poisons of known chemical nature, and in the forage diseases reported from South Africa we find examples of "periods of incubation lasting as long as eighty to ninety days in horses, after the last occasion on which the poisonous plant was eaten."

(6) By what mechanism is the toxin transported to the reacting cells of the spinal cord and brain? Is it taken up by them from the blood stream, as is the

case with alcohol, numerous alkaloids and many other substances? One of the most revolutionary theories ever proposed in medicine asserts that the toxin can not be taken up from the blood stream by the reactive cells of the central nervous system, but can be absorbed by them only when (1) it is transported to them in the nerve fibrils or axons of the motor nerves, or (2) when it is transported to them in the endo- and peri-neural lymphatic vessels of these nerves. According to these theories, then, the motor nerves of the vertebrates have the hitherto unsuspected ability to transport a soluble substance from the periphery into the spinal cord. Some of the latest converts to the theory believe that the cerebrospinal fluid also receives its share of the toxin. The experiments that have been made during the past thirty years or more in support of this nerve transport theory have been so well designed and so skilfully performed by men of the highest standing, and have appeared to be so valid and irrefutable, that this unusual and exceptional mode of transport of a soluble substance has been universally accepted as an entirely satisfactory explanation of the facts of the case. Speransky and his coworkers, Ponomarew and others, have recently performed a great number of ingenious experiments with the toxin and have interpreted their findings in a manner that encouraged them to announce a third variant of the neural transport theory. They appear to be firmly convinced that the toxin and other substances that may be absorbed by the terminals of a mixed nerve, such as the sciatic, are conveyed to the cerebrospinal fluid and the substance of the cord in the tissue spaces of the nerve. I can not pause here to give an analysis of their experiments. We should have to take into consideration known facts in respect to the pressure of the cerebrospinal fluid which in the lumbar theca of a man in the recumbent position varies from 80 to 120 cm, in terms of a Locke's solution, and then inquire whether an individual with the natural disease, due to a strictly localized infection, say of the foot, would ever develop such an enormous increase of the normal tissue pressure of his foot (2 to 6 cm) as would be necessary to propel the toxin from the foot to the subarachnoid spaces of the cord—even if there were a direct and open pathway or channel to the cord. But we are not dealing in normal tissue spaces with uninterrupted continuous channels. This matter will be considered more at length in a later section of this address. We have now three variants of the neural transport theory of tetanus toxin, and it is hardly likely that the ingenuity of investigators will enable them to invent a fourth. During the world war the attention of bacteriologists, pathologists and surgeons was again directed to various aspects of tetanus. Much of the earlier experimental work on which the neural transport theory is based was repeated, with the result that some scientists now accepted carriage of the toxin both by way of axis cylinders and neural lymphatics, while others were led to believe that the latter mode of transport suffices and is indeed the only one that can be accepted. In recent years a Japanese investigator has also published a paper in favor of this mode of transfer of the toxin to the spinal cord.

(7) It has just been stated that the theory of transport of toxin to the central nervous system by motor nerves has three variants. Let us consider first the variant that assumes that the axis cylinder is the pathway. It is evident that the toxin can not travel this pathway by diffusion, as this process is so very slow that it can not be made to explain the latent period or its variations in time. The proponents of the theory therefore assume that the toxin is propelled in the axis cylinder by a "protoplasmic streaming." As this process is also assumed to be one of slow character, it appears to account very nicely for the varying periods of incubation in small and large animals. In the smaller animals, such as mice and guinea pigs, with their shorter nerves, the time of transport would be less and would account for the shorter period of incubation in these animals.

In laboratory experiments large quantities of the toxin, often amounting to many times the average fatal dose, were injected beneath the skin of the leg of an animal, and it was found that the nerves in close proximity to the point of injection absorbed some of it. If only two to five fatal doses were injected, only the more peripheral parts of the nerve were found to contain it, while the more centrally lying parts contained none. The proof of its presence in the nerves is given by injecting the crushed nerve or an extract of it into a much smaller and more susceptible animal, such as the mouse. In any case, however, even when very large doses of the toxin are injected, the amount of toxin present in the entire nerve amounts to only a very small fraction of what was injected. The entire sciatic nerve of a full-grown cat or rabbit of average size weighs about a gram. One of the upholders of the axon transport theory found indeed that after subcutaneous injection of one minimal lethal dose into the hind leg of a rabbit not enough toxin could be recovered from the sciatic nerve to kill a small mouse, that is to say, not even $\frac{1}{25,000}$ part of what was injected was present in the nerve. Now facts of this kind are not offered here in disproof of this variant of the transport theory now being discussed, as it may be assumed that the actual amount of toxin required by the central nervous system for the induction of convulsions must be very small indeed, and on theoretical grounds the assumed steady transportation to it of very small

amounts of toxin in a unit of time might well suffice to affect the central nervous system, if this mode of transportation could be proved to exist. The occurrence of a very interesting and puzzling phenomenon was early noted in laboratory experiments with various small animals that had received the toxin by subcutaneous, intramuscular or intraneural injection into one of the extremities, as the hind leg, let us say. After an interval of time varying from 17 hours to four days, the muscles of the injected leg become so rigid that all freedom of movement disappears, the leg is stiffly extended and so useless that the animal walks on three legs. This spastic paralytic condition is called a local tetanus, and it is certainly a striking occurrence in that it often persists for three or four days before the muscles of the trunk or the other extremities become involved. If the injected dose is small the local tetanus finally disappears and the animal regains its normal state. This local tetanus is the corner-stone of the foundation on which the theory is built. It was assumed that in the experiments just described the toxin travels along the axis cylinders of the sciatic nerve, in the peripheral parts of which it is generally found, to the spinal cord. The motor cells of the spinal cord receiving the toxin from the nerve are thrown into a condition of hyperexcitability, lasting for some days, and in this way the cause of local tetanus is supposed to be satisfactorily explained.

The theory of carriage by nerve fibrils rests on several unproved assumptions: (1) There is no experimental evidence that there exists anything in the nature of a slow "protoplasmic streaming" or current in the axis cylinders of nerves; (2) when the toxin is found to be present in an excised piece of a nerve, such as the sciatic, there is no trustworthy evidence that an appreciable amount of it is present in the axis cylinders and that the capillaries and the endo- and perineural lymph vessels of the nerve do not contain practically all of it. It has been repeatedly shown that the lymphatic capillaries readily absorb the toxin from an injected area, and there is no sound reason for believing that the lymphatics of any nerve in the immediate vicinity of the area do not also absorb it. That "the three types of peripheral neurones, the motor, the sensory and the sympathetic, are equally able to absorb the tetanus toxin," was conclusively proved by Morax and Marie thirty years ago, who, however, nevertheless assumed that the toxin is carried upward by motor fibrils only. The findings of these authors were criticized on the ground that absorption of toxin by the neural lymphatics could not be excluded. In our day, however, carriage by the neural lymphatic seems to be the prevailing theory. In any event, how can the theory of the exclusive transport by the neurons of motor nerves be any longer upheld, in view of the observations of the French authors just cited? (3) The theory was devised to explain local tetanus and was then applied to all cases of generalized tetanus in which no local tetanus appears. Now neither this theory nor either of its two associates can be reconciled with the following observations which were made in my laboratory by myself and my assistants a number of years ago. That lower vertebrate, the frog, is susceptible to the tetanus toxin and reacts to it with convulsions. There is no reason to believe that the proposed axis cylinder transport theory will not hold for this animal as well as for the higher vertebrates and man. Numerous experiments were made on frogs with alkaloidal convulsants and with convulsant dye stuffs. In the case of the latter convulsants their presence can be detected in the brain and spinal cord aftey they have exerted their action. It was very conclusively shown that all these convulsants can reach the reactive cells of the brain and cord by one pathway only, namely, by the circulating blood. Ever since those experiments were made I have entertained serious doubts in respect to the validity of the current nerve transport theory, which goes so far as to deny the possibility that the cells of the central nervous system can abstract the toxin from the circulating blood. Pochhammer has shown that local tetanus appears in the muscles of the hind leg of a rabbit that has received a subcutaneous injection of a lethal dose of toxin into the lower leg, *before* toxin can be detected in the sciatic nerve, and his findings have been fully substantiated by Sawamura, who, however, minimizes their significance, on quite inadequate grounds in our opinion. We have not yet repeated this experiment, but there can be no doubt of its correctness, and it certainly gives little support to the theory that local tetanus is due solely and entirely to an early invasion of the spinal cord by toxin by way of motor nerve fibrils. It is surely difficult to bring the fact that the peripheral parts of a nerve contain no demonstrable amount of toxin until *after* local tetanus appears, into agreement with the theory. The adherents of the theory will perhaps maintain that a small amount of the toxin was carried to the cord even though it could not be detected in the nerve.

We will not offer here a theory in respect to the true nature of local tetanus or inquire to what extent a myogenous factor is more largely involved in that form of tetanus than in the spasms of descending tetanus. I would remark, however, that the rigid, unremitting, long-continued closure of the jaws that we have observed in our experiments with horses and sheep, and that is so frequently found in man suffering from the natural disease, can hardly be distinguished from the local tetanus of a hind limb of

a dog. In our opinion no such significance attaches to local tetanus as to warrant making it the basis of a theory of carriage of the toxin to the central nervous system, either by way of the axis cylinders, the lymphatics or the tissue spaces of nerve trunks. Had not this form of tetanus been so generally observed in laboratory experiments with small animals after the injection of lethal or sub-lethal doses of toxin into them, it is very improbable that a neural transport theory would ever have been proposed. It has long been known, not only to the few opponents of the theory, but also to its numerous adherents, that local tetanus can be made the antecedent phenomenon to descending tetanus or not, as desired. In the dog or rabbit one can produce a most striking and lasting local tetanus which is later followed by spasms in other muscles, or one can so choose the site of injection and so regulate the dose of toxin that generalized descending tetanus occurs without the appearance of a definitely recognizable local tetanus. Zupnik was the first to show that even in the small animals used in laboratory experiments, local tetanus does not occur if the toxin is injected in the neighborhood of certain joints or into the tip of the toe or the dorsum of the foot. After the usual period of incubation in such experiments only *tetanus descendens* appears. Here again we have evidence that proves conclusively that local tetanus can only appear when the muscles in question are exposed to a sufficient *concentration* of the toxin and for a sufficient period of *time*. May I lay emphasis on these two conditions as indispensable to the appearance of local tetanus? There are other very striking experiments, which can not be detailed here, that indicate that local tetanus may be entirely or almost entirely averted in the dog, if the animal is made to perform hard work on a treadmill for six or more hours a day. The control animal that had received an equal dose of the toxin and was confined to its cage developed local tetanus in its most perfect form. We can not for a moment agree with Ponomarew in his interpretation of this experiment, which was first performed by him. We have repeated the experiment with great success by exercising our dogs vigorously and for longer periods of time, and in our opinion absence of local tetanus in the working dog is best explained by the assumption that the poison is rapidly removed by the capillaries anl lymphatics of the injected limb in consequence of the increased circulation and the metabolic events associated with activity.

We may now consider briefly the second variant of the nerve transport theory, which states that the toxin is carried to the central nervous system by way of the endo- and perineural lymphatics. Professor Lee and his assistants have kindly performed, after consultation with us, a considerable number of experiments of different types on large dogs to test this theory. In one type of the experiments one sciatic nerve of a dog was sectioned high up in the thigh at a convenient distance below the trochanter major, and the severed parts of the nerve were then very carefully sutured so that the continuity of the perineural sheath was restored. Naturally, all these operations were done in an aseptic manner. After the lapse of a month or more, the nerve was again exposed and one or more lethal doses of tetanus toxin, either in the form of a toxic filtrate or in the form of a solution of the dry toxin, were injected into the nerve several centimeters distal to the point of suture. At the time of the injection it was assumed that the lymph passages across the line of transection and suture had been regenerated and were capable of functioning normally. Aside from the symptoms that appeared in the injected leg, which we can not pause to describe here, it was found that generalized tetanus of the usual type occurred in the animal exactly as would have been the case had the toxin been injected into an intact sciatic nerve. It is evident that the poison could not have reached the cord by way of the degenerated axis cylinders of the sciatic, nor do we stress this point, as the advocates of the theory have always admitted that degenerated axis cylinders can not convey the poison. The advocates of the lymph transport theory will, however, find strong support for their belief in the results of this experiment. They will very naturally assert that the toxin was first transported to those centers of the spinal cord that have a functional connection with the muscles of the infected leg, and they will also hold to their belief that the large amount of the toxin that escaped from the nerve and found its way into the circulating blood was in its turn absorbed by the lymphatics of the other motor nerves of the body and transported by them to other parts of the central nervous system than those of the lower cord. We have here a fine example of the difficulties so often encountered in physiological and pharmacological experiments, namely, that the results can apparently be interpreted in at least two ways. It is a singular fact that the advocates of this theory have apparently never asked themselves the question, Where does the lymph of a nerve-trunk such as the sciatic go? The theory that we are now discussing implies that the lymph of all our peripheral nerves regularly, together with such substances as it may have taken up from the environment, finds its way to the spinal cord and the cerebrospinal fluid. Unfortunately for the advocates of this theory, a number of anatomists have finally answered the question. They have traced the course of the lymphatics of the nerve-trunks of both the fore and hind limbs. As in the case of the fore limbs, the lymphatics of the nerves of the leg accom-

pany the arteries of the nerve and throw their contents into more deeply-lying "collectors." In all cases the lymph finally reaches lymphatic glands of the general lymphatic system. Thus, those of the upper part of the sciatic reach deeply lying inguinal glands, and those of its lumbo-sacral trunk finally empty into the hypogastric lymph glands. In a word, we derive no evidence from the study of anatomists that the lymph of any of the peripheral nerve-trunks finds its way into the spinal cord or the cerebrospinal fluid. It may be recalled at this point that the nerve roots within the spinal cord have no perineural sheath and are covered only by the thin neurilemma. It is gratifying, indeed, to have at our disposal these anatomical findings of the last few years in regard to the disposal of the lymph of nerve-trunks. It would be a remarkable fact if the central nervous system in all its parts—a system in which, according to neurologists and anatomists, there are interposed "barriers" that protect its cells from a too ready entrance into them of a great number of soluble substances—should be so accessible to all the numerous substances that can enter the lymphatics of the nerve-trunks at so many points in the body. An experiment that was made by me on frogs many years ago proves how difficult it is to introduce a powerful convulsant, such as strychnine, into the spinal canal in the case of the frog after excision of its heart and complete destruction of its four lymph hearts. A frog that has been treated in this way, and all of whose abdominal organs have been carefully removed without opening any one of the calcareous saccules that lie close to the spinal column, can be immersed in a quarter per cent. solution of nitrate of strychnine in Locke's fluid, kept oxygenated at a temperature of 12° C. for half an hour or more, without the appearance of any convulsions whatever. After removal of this "reflex-frog" from the strychnine bath and carefully washing away every trace of strychnine with cold water, it is found that it responds at once to the injection of a small amount of strychnine into the exposed spinal canal with typical strychnine convulsions. How many hours it would take for the strychnine of the bath to penetrate into the spinal canal by the slow process of diffusion, I have never determined. The experiment, however, shows very conclusively how difficult it is to introduce a rapidly acting and powerful drug into the central nervous system by any other path than by the arterial route. I may conclude this part of my address by stating my conviction that in the natural disease, tetanus, there is no carriage of the toxin to the central nervous system either by way of nerve fibrils or by way of neural lymphatics, and that the only route by which toxin can be carried to the cells of that system is the arterial pathway.

Let us now consider again the more recently proposed third variant of the neural transport theory, stating that the toxin is conveyed to the central nervous system by way of the tissue spaces of nerve trunks. The proponers of this theory, Speransky, Ponomarew and Wischnewsky, rest their claims on certain anatomical beliefs and on the supposed validity of deductions drawn from the results of intraneural and intramuscular injections of the toxin. We find that our experimental and critical analysis of the experiments of these investigators (which will be published in a later paper) does not support their theory in the slightest degree. Some anatomists have expressed the opinion that the tissue spaces (*Lymphräume*) of nerve-trunks, which must be differentiated from lymphatic capillaries, stand in connection with the subarachnoid and subdural spaces of the brain and spinal cord (*"im Zusammehnang stehen," Shdanow*). The tissue pressure is not of sufficient magnitude to move solutions through such narrow spaces, frequently interrupted as they are by barriers. It is freely admitted that diffusion goes on in tissue spaces of organs, as witness the lens, whose low metabolic requirements are met solely by this slow process. Diffusion can be effective only in a short space of time when it operates in structures of minute dimensions, as in the pulmonary alveolar capillaries whose wall thickness is only one thousandth of a millimeter. It would be impossible for the slow process of diffusion to do the work necessary for the maintenance of life in the four seconds of each respiratory act, were not the interposed barriers extremely thin. The minute tissue space mechanisms are energized by molecular forces only (surface energy and diffusion), and it remains to be proved that such forces can compass the astonishing feat of transporting a poison over long distances and through intervening cell barriers to the central nervous system. My associates and I have shown that, in the frog, even the foramina through which the nerves and blood vessels enter or leave the bony encasement of the spinal cord are guarded against the entrance of solutions by any other than the vascular route. Injections of suitable solutions or masses in large amounts for the purpose of outlining the entire course of arteries, veins or lymphatics are legitimate operations, since preformed pathways are utilized in experiments of this nature. But when a solution of toxin (0.1–0.3 cc and more) is injected into a living nerve-trunk, such as the sciatic of a cat or rabbit, for example, the needle of the syringe rarely if ever enters one of the veins or lymphatics of the nerve. The non-rigid, soft and distensible nerve is greatly dilated at the point of injection and the resulting internal pressure forces the solution both downward and upward in artificially formed paths. It is not permissible to believe, on the basis of such experiments, that anything of this

kind occurs in the *natural* disease, even when the terminal portions of the nerve have absorbed some of the poison from the infected area. We have often examined toxin-containing nerves, after *subcutaneous* injections of the poison, and have never observed that they differ in appearance from corresponding non-poisoned nerves. There is little likelihood of an increase in the normal tissue pressure of such nerves and little possibility here of a forcible transportation of the toxin to the central nervous system in mechanically produced pathways in the connective tissue spaces of the nerve, as is the case in nerves that have been distended by an injection. Furthermore, is it not more than likely that such of the toxin as may find its way into the tissue spaces of a nerve-trunk in proximity to the infected area, in the *natural* disease, if indeed assumption of toxin by the peripheral nerves occurs in that case, could not be carried far centrally but would be removed from these spaces by the capillaries and lymphatics? We have seen that the lymphatics of nerve-trunks finally discharge their contents into more deeply lying collectors and lymph glands that communicate with larger lymphatic trunks. Support for this opinion is found in the well-known fact that the middle and upper portions of the sciatic nerve do not contain a demonstrable amount of toxin after this has been injected subcutaneously in the region of the gastrocnemius muscle in such considerable amounts as from two to five lethal doses.

Distribution of Tetanus Toxin in the Body

During the past forty years and more, many investigators have shown that the toxin may be present in the spleen and liver for a short time after injection into the animal and that it persists for a longer time in the blood, lymph, lymph glands and in the peripheral parts of mixed nerves and that it also appears occasionally in the urine. It has never been found in the muscles. All this early work was of a qualitative character only, that is to say, no attempt was made to determine with any degree of accuracy how much toxin was injected and how much of it could be recovered from the blood and lymph and other parts of the body. A few quantitative experiments were made by Bieling and Gottschalk, who injected known amounts of the toxin directly into the heart of guinea pigs and then assayed the toxin content of the blood and of extracts of various organs within an hour after the injection. The results of these authors are often cited as showing that a large amount of the toxin soon disappears from the blood and that this part is either irreversibly bound or rendered inactive in various tissues and organs of the body. More than thirty years ago, Ransom, alone among early investigators, attacked the problem of the distribution of both tetanus toxin and antitoxin between the blood and lymph in a more serious manner in many experiments on dogs. After injection into the blood stream of known and large amounts of the toxin it was found that about 26 per cent. of it had disappeared from both the lymph and blood in three hours, and after the lapse of 26 hours somewhat more than 70 per cent. of what had been injected had disappeared from the two fluids. Ransom also showed how rapidly the toxin passes into the lymph after intravenous injection and that the two fluids contain an equal amount of the toxin in equal volumes after the lapse of 26 hours. The fact that in the relatively insensitive dog the toxin disappears so rapidly from the blood and lymph is in striking contrast with our own experiments on a much more sensitive animal, the sheep.

In repeating and amplifying the earlier work of this character we have aimed primarily at the establishment of values that are easily reproducible and as accurate as our methods would permit. The quantitative data of experiments of the kind here offered are inevitably burdened with the fluctuations due to variations in the response of animals to the action of a given poison and it is therefore necessary to assemble enough data to satisfy the requirements of statistical theory and thus reduce the disturbing action of variations of unknown cause to such a degree that the conclusions thus arrived at will be valid within certain limits. We have attempted to interpret our data in accordance with this principle, but can not here give the details of our methods of assaying the amount of toxin injected by various pathways or that found to be present in the blood and lymph on subsequent days. The animals used for assaying the injected toxin and that present in the blood of the infected sheep were guinea pigs of standard age and weight, and more than a hundred of these testing animals were used for each sheep. The variation in the values obtained in these experiments is probably on the average not more than 10 per cent. and we believe that this figure represents a degree of precision far exceeding that of earlier estimations.

We have found sheep to be the most satisfactory experimental animals for these studies and have investigated the toxin content of the blood and lymph of a series of nine of these animals of approximately the same weight and after the administration of comparable doses of tetanus toxin by several routes. At the time the toxin was injected into the animals the toxicity of an aliquot portion was again carefully determined in the usual manner. Thereafter daily estimations of the toxin content of the blood were made. In this manner, a complete record of the daily variations of the toxin content of the blood of an experimental animal was obtained.

After an intravenous injection of 35.6 guinea pig minimum lethal doses of toxin per kilogram of body weight into a sheep, the toxic content of the blood fell to 60 per cent. of the injected dose at the end of 24 hours. Forty-eight hours after the injection the blood and lymph each contained, volume for volume, equal amounts of the toxin which in the blood was still maintained at the level of 50 per cent. of the injected dose, if it can be assumed that the total amount of blood in the sheep was 6.6 per cent. of its body weight. In this animal, whose lymph had been collected on one day, the blood content in toxin dropped to less than 30 per cent. of the injected dose at the time of death. In a second animal that had not been subjected to the long operation involved in the collection of the lymph from the thoracic duct, the blood content in toxin, after intravenous injection of 53.3 guinea pig minimum lethal doses of tetanus toxin per kilogram of body weight was also estimated. One hour after the injection the blood contained 90 per cent. of the injected toxin; seven hours after the injection 60 per cent.; after 24 hours again 60 per cent. This high level was maintained up to the first appearance of trismus on the third day after the injection. Thereafter the toxin content of the blood dropped, being somewhat less than 40 per cent. at the time of death on the sixth day after injection.

When a standardized quantity of toxin amounting to from five to six lethal doses is injected at one time into a sheep, the blood and lymph content of toxin finally reach much the same level, irrespective of the site of injection, whether this be the tip of the tail, the subcutaneous tissue of a leg, the interior of a muscle or a vein. We give here two instances in which intramuscular injections were made. One of the two sheep received, by this route, 49.6 guinea pig minimum lethal doses per kilogram of body weight, while the second received 54.1 guinea pig minimum lethal doses per kilogram. The toxin content of the blood of these animals varied from 40 to 50 per cent. of the amount of toxin injected and was maintained at this high level during the three to five days that preceded the onset of symptoms. It is indeed extraordinary that the highly toxic blood can penetrate every region of the body during the several days of the incubation period without apparently manifesting any evidence of its poisonous nature. An analogous instance is that of the action of certain convulsant dyestuffs on frogs when the blood, surcharged with dyestuff, also circulates for a certain time without exhibiting any signs of toxicity. And many other examples of this kind are known, but I can not be sure at the moment that the blood content of poison during the period of incubation has actually been determined for any of them. In the experiments under consideration the toxin content of the blood dropped somewhat after the appearance of general symptoms but was still present at a concentration of 20 to 30 per cent. of the injected dose at the time of death. With the assistance of Professor Lee we collected the lymph from the thoracic duct of one of our sheep, 36 hours after it had received an intramuscular injection of 40.7 guinea pig minimum lethal doses of tetanus toxin per kilogram. Just before the operation for the collection of lymph, the toxin content of the venous blood of the sheep was 40 per cent. of the amount injected. At this time, the lymph contains, volume for volume, an amount of toxin equal to that in the blood. Unfortunately we have no reliable data in regard to the total volume of lymph in the higher animals, and for this reason an estimate of the actual percentage of the injected toxin present in the lymph can not be made. However, it is apparent that after intramuscular injection of the tetanus toxin, as after intravenous injection, an equilibrium exists, if we may term it so, between the blood and lymph in the sense that equal volumes of both fluids contain equal amounts of the toxin. Could we assume, as was done by Ransom in his experiments on dogs, that the total amount of lymph in the entire lymphatic system, inclusive of the lymph glands, can be conservatively estimated as equal to that of the blood, we would be in a position to affirm that fully 90 per cent. of the injected toxin is present in the blood and lymph of sheep under the conditions of the experiments here described.

We have also made an experiment in which a total of 1,600 guinea pig minimum lethal doses (45.7 guinea pig lethal doses per kilogram of body weight) were injected intramuscularly into a sheep. This quantity was not injected at one time but was divided into sixteen portions, and these were injected into a limited area of a shoulder muscle at regular intervals over a period of thirty-two hours. On comparing the toxin content of the blood of this animal with that of a sheep receiving a markedly smaller dose of toxin (40.7 guinea pig minimum lethal doses per kilo) in a single intramuscular injection, we find that only 30 per cent. of the injected toxin was present in the blood during the incubation period as compared with 40 to 60 per cent. in the blood of the second animal at the same time. It is evident that the amount of toxin bound by the tissues is relatively greater when it is introduced into the body in small amounts over a period of time. The situation is somewhat more comparable to that observed in the natural disease than when a large dose is injected at one time.

Perhaps the most striking fact that has been established by these studies is the persistence of the toxin, in high concentration and over a long period, in the vascular and lymphatic systems of the animal. That such surprisingly large amounts of the toxin can be

shown to circulate in the blood and lymph up to the time of the death of an animal is indeed surprising when we recall the unanimous opinion of other workers in this field that the toxin is rapidly, and, to a very considerable degree, detoxified or bound by the animal tissues.

It will be seen from the above account of our investigations that my associates and I have come to the conclusion that the theory of carriage of tetanus toxin to the central nervous system by way of the peripheral nerves is no longer tenable. In so far as this poison reaches the central nervous system it can do so only by being brought to it by the arterial blood. The various aspects of the disease have been the subject of intensive investigation by clinicians, bacteriologists, immunologists, physiologists and pharmacologists during the past fifty years. A great body of frequently conflicting facts has been brought to light, but there is little agreement in respect to their explanation. Four different theories have been proposed to explain local tetanus and four more have been devised to show the pathways by which the toxin reaches the central nervous system. We have discussed three of the second quartet as variants of the neural transport theory. The fourth, which receives our hearty support, states that the toxin can reach the central nervous system only by way of the blood stream. In regard to the exact nature of the poison or poisons concerned, their possible alteration in the animal body and the manner in which they induce the formation of an anti-body, we are without definite knowledge. All these questions are of great significance and have an important bearing on the mode of action of bacterial toxins as a class. It will no doubt require the united efforts of many investigators for many years to find an adequate solution of these and other fundamental problems of this disease. We are continuing our work in the hope of throwing some light on one or another of these difficult questions.

ORGANIZED INDUSTRIAL RESEARCH[1]

By Dr. W. D. COOLIDGE

DIRECTOR OF RESEARCH LABORATORY, GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

Thirty years ago an industrial research laboratory was still a novelty. Professor Elihu Thomson, Mr. Edison and Dr. Steinmetz had made many of their great individual contributions, and it was because of the traditions built up by them that Dr. E. W. Rice, then technical director of the company, had decided to embark on the new experiment—*organized* industrial research. The value of science to industry had not yet come to be generally recognized, nor had industry yet convinced science that a union of the two could be anything but a misalliance. Many scientists in that day felt, and some openly proclaimed, that to apply to industrial problems scientific brains and scientific methods was to debase them.

Let me say as emphatically as I can that I yield to none in my appreciation and admiration of those scientists who, in academic surroundings, with little thought of financial reward but with a passion for knowledge and an eye single to the truth, are pushing their researches even farther into the unknown, and broadening and deepening the foundation of science on which our civilization rests. For our civilization is an engineering civilization which could endure scarcely a day if all the products of engineering were suddenly swept away, and it is science which serves as the basis of engineering. So the most cloistered scientist, however remote from the marts of trade and however innocent of the least thought tinged with utilitarianism, is perhaps, all unknown to him, preparing the way for some new appliance for the service of mankind, some appliance perhaps that will bring new industries into being. When Professor J. J. Thomson, in his university laboratory, by a beautiful experiment first determined the charge of the electron, he certainly had no thought of any interest but that of pure science, of extending our insight into the fundamentals of things. He surely did not foresee the great new industry of radio broadcasting which was to bring employment to tens of thousands and entertainment and instruction to millions. But Professor Thomson's work helped to lay the foundations of that industry, just as truly as did the other beautiful experiments and keen analysis of Langmuir, when in our own laboratory, he discovered the space charge effect, the effect produced in vacuum by those very charges which Professor Thomson had measured, the effect which, when understood, made possible for the first time the design of high power vacuum tubes suitable for radio broadcasting.

And I venture to say this—and this is the point to which I have wished to lead—that Langmuir in his work, like Professor Thomson, was absorbed wholly in the pursuit of truth, and the attainment of new, fundamental facts was for him an all-sufficient goal.

[1] An address given at a meeting of the American Institute of the City of New York on February 1, 1934, when a gold medal was presented by the institute to the General Electric Company "for pioneering in industrial research."

It was sufficient goal for our laboratory, too. That was the first source of my pride in our company—that in our laboratory, under the directorship of Dr. Whitney, fully supported by the authority of Dr. Rice—research in pure science was not only permitted but encouraged, with no demand for immediate practical results. The criterion for such work was not whether it promised direct financial returns, but whether it was likely to be productive of new facts to broaden the base of the scientific knowledge on which our industry rests.

To-day, industrial research has repeatedly and amply proved its financial value, so that the research laboratory has become a practically indispensable part of any large manufacturing organization; but, in retrospect, it seems to me that the recognition more than thirty years ago of the potential ultimate value, to an industry, of research in pure science showed extraordinary clearness and depth of vision.

From the beginning, along with our work on the various practical problems arising from engineering and manufacture, we have carried on much work in pure science—in physics, in chemistry, in metallurgy and in mechanics; we have been free to publish our results and have been encouraged to do so; we have had the satisfaction of knowing that we were making real contributions to the sum total of fundamental scientific knowledge and were gaining the respect and confidence of fellow scientists in academic circles. That such conditions have always prevailed in our company is, I think, ground for pride in our laboratory.

And later I discovered another source of pride. I can best illustrate it by an example. In the early days of our laboratory we made a series of discoveries—first on the metallization of carbon, then on the metallurgy of tungsten, and, finally, on the heat conductivity of gases and on the effect of gas pressure on the vaporization of tungsten—which enabled the General Electric Company to play a major rôle in increasing the efficiency of incandescent lighting to more than six times what it was when our laboratory was first started. For this our laboratory claims by no means all the credit. Much is due to the engineers and factory men, for the development of improved designs, new factory processes and marvelously efficient automatic machines. (This is why the presentation of a medal to a company rather than to an individual seems fitting.) As a result of this conjoint effort, the cost to the public of electric light has been reduced to a small fraction of what it was thirty years ago, for the benefit of each improvement has been promptly passed on to the public in the form of better and more efficient lamps at a price representing only a fair profit. Thus, for each dollar of profit the company has made on its lamps, the public has enjoyed savings amounting to hundreds of dollars—as can easily be shown by figures.

Many similar examples could be given. I soon realized that while employment in the Research Laboratory of the General Electric Company placed a worker in science at no disadvantage as compared with his academic confrères (in respect to freedom to pursue new knowledge), it gave him the advantage arising from satisfaction in seeing his scientific discoveries promptly and effectively applied, not only for advancing the industry, but also truly serving the public.

So to-day we see the results of past researches in metastable atoms and plasmas being progressively embodied in new and more efficient lamps having sodium vapor as the illuminant, just as in the past our investigation of heat conduction and tungsten evaporation in gases gave us the gas-filled incandescent lamp; we see our studies of cold cathode effects (field currents) in high vacuum leading to higher voltage tubes for x-ray production and other purposes; researches in surface chemistry have given us better photoelectric tubes and perhaps are about to give us better lubrication; studies in mechanical balancing has given us better and quieter rotating machines; and from fundamental studies in chemistry are coming new and better synthetic resins.

Sometimes a new fact remains long sterile until the stimulus comes which vitalizes it to produce some new practical result. For instance, our observation of the dissociation of hydrogen in contact with a hot tungsten filament was made nearly ten years before another observation, at the Johns Hopkins University, suggested the utilization of our phenomenon in a new form of welding, now known as the atomic hydrogen welding process.

Investigation often reveals relationships between phenomena in seemingly widely separated fields. For instance, who but the scientist would ever have suspected the close relationship now known to exist between the structure of oil films on water and that of the electron-emitting surface of the highly efficient thoriated filament of radio tubes?

So, along with our work on diverse practical problems, we are vigorously continuing researches in fundamentals—in electronics, in magnetics, in high pressure electrical discharge phenomena, in metallurgy and in mechanics. Even through the most severe part of the depression, although all activities were somewhat curtailed, our researches in pure science were permitted to continue with only slight diminution. We continue in full faith, based on past experience, that each new fact will sooner or later find its useful application, if not in the field of interest of the General Electric Company, then somewhere else. Our investigations of high frequency fields have already

been of value to the medical profession. Our studies of the effect of x-rays on plants may yet be of assistance in horticulture or agriculture.

It is true that the field of interest of the General Electric Company is so broad that the chance that a new fact will find application in that field is good, and our company for that reason is more likely to benefit directly from research in pure science than would a company occupying a narrower field. But that is only a matter of degree, and, to my mind, detracts not at all from the credit due to the vision that foresaw the potential value of broad industrial research and to the courage that assumed the risks of pioneering.

While our laboratory, as I have said, was organized definitely for the purpose of industrial research and has always been known as the Research Laboratory of the company, it has had, by no means, a monopoly of the research work of the company. Important and fruitful researches have been conducted in the Thomson Laboratory at Lynn and in several of our so-called works laboratories, as well as in the lamp laboratories at Cleveland and the General Engineering Laboratory at Schenectady. Therefore, in speaking of the company's research, the contributions of all these laboratories must be included.

I have thus far spoken only of those company policies which have most directly concerned our laboratory, but I feel pride in our company on other grounds.

Mr. Owen D. Young has often spoken of the threefold obligation of a manufacturing corporation—to its customers, to its stockholders and to its employees—giving to its customers a product of high quality and reliability at a fair price; to its stockholders an adequate and assured return on their investments, and to its employes safe, pleasant and healthful working conditions, fair wages, assured employment and assistance in safeguarding themselves against the disabilities of injury, sickness and old age. I know of no company that has striven more earnestly than ours to fulfil those duties scrupulously. Other companies also have made a fine record in quality of product and in continuity of dividends, but in connection with the third duty—that of human relations—I feel that our company has again pioneered and deserves special credit. Under the leadership of Mr. Swope and Mr. Young, great effort has been made to improve working conditions, to pay as high wages as competition would permit, and to insure, as far as a single corporation could, continuity of employment. Equal effort has been made to provide (with assistance to self-help rather than through paternalism) relief against unemployment and retirement from either disability or old age, through unemployment relief and pension funds, built up by contributions from employe and company alike on a dollar for dollar basis. And employes have been encouraged and assisted to own their own homes and to make safe and profitable investments.

It is therefore both with a keen sense of the signal honor conferred, and with a reassuring conviction that the honor is fairly merited, that I gladly and gratefully accept, in behalf of the General Electric Company, this gracious award by the American Institute.

OBITUARY

MEMORIAL TO THE LATE THOMAS WILLIAM SALMON

A bas-relief portrait of the late Dr. Thomas William Salmon, first medical director of the National Committee for Mental Hygiene, was presented to the New York Psychiatric Institute and Hospital, Columbia-Presbyterian Medical Center, by the Thomas William Salmon Memorial Committee on the afternoon of January 26.

The presentation was made by Dr. William L. Russell, professor of psychiatry at Cornell University Medical School, for the Salmon Memorial Committee, and the tablet was accepted by Dr. Frederick W. Parsons, commissioner of the State Department of Mental Hygiene. Dr. William Darrach, dean emeritus of the Columbia University School of Medicine, delivered the memorial address. Dr. Clarence O. Cheney, director of the institute, presided. After the ceremony an informal tea was given at the institute in honor of Mrs. Salmon.

The tablet, executed by Charles Keck, of New York City, represents a figure of Dr. Salmon in profile, with the following inscription:

Professor of Psychiatry Columbia University 1921–1927
Beloved Physician Teacher Mental Hygiene Leader Whose
Vision Guided the State and the University in Placing
Here This Psychiatric Institute and Hospital

Dr. Salmon, who died on August 13, 1927, was professor of psychiatry in the Columbia School of Medicine and first proposed the cooperation of New York State with Columbia University and the Presbyterian Hospital in establishing a State Psychiatric Institute and Hospital as part of the Columbia-Presbyterian Medical Center. It is particularly in recognition of this service that the presentation of a memorial tablet to the New York State Psychiatric Institute and Hospital is being made.

Following Dr. Salmon's death, his friends and former associates organized and incorporated the

Thomas William Salmon Memorial Committee to perpetuate his memory. This committee has raised a fund for providing annual lectures in psychiatry and to promote research in this field. The plans of the memorial call for a series of lectures to be delivered each year.

Dr. Adolph Meyer, professor of psychiatry at the Johns Hopkins University, received the first award of the Salmon Memorial. His lectures on psychobiology, which were given in New York on April 8, 15 and 22, 1932, will shortly appear in book form. The lectures this year will be given at the New York Academy of Medicine on April 13, 20 and 27 by Dr. C. Macfie Campbell, professor of psychiatry in the Harvard Medical School.

RECENT DEATHS

Dr. Warren Upham, formerly of the U. S. Geological Survey, geologist and archeologist, died on January 29. He was eighty-three years old.

Dr. Walter James Highman, specialist on diseases of the skin and dermatologist at Mount Sinai Hospital, New York City, died suddenly on January 24, at the age of fifty-four years.

Sir Donald MacAlister, chancellor and for many years principal of Glasgow University and president of the General Medical Council, died on January 8 at the age of seventy-nine years.

Dr. Finlay Lorimer Kitchin, paleontologist to the Geological Survey of Great Britain, died on January 20 at the age of sixty-three years.

Dr. William Edward Gibbs, Ramsay professor of chemical engineering at University College, London, died on January 18 at the age of forty-four years.

Dr. Benjamin A. Bensley, professor of zoology and head of the department of biology of the University of Toronto, died suddenly on January 20. He was fifty-eight years old.

Dr. Fritz Haber, professor of physical chemistry at the University of Berlin and director of the Kaiser Wilhelm Institute for physical and electro chemistry, Nobel laureate in 1919, died suddenly on February 1, at the age of sixty-five years.

SCIENTIFIC EVENTS

STRATOSPHERE FLIGHTS

Two stratosphere ascents to the highest point to which it is practicable for a balloon to lift a man will be made in the United States during the coming summer, according to an announcement made jointly by the National Geographic Society and the U. S. Army Corps, sponsors of the project. The balloon, with a capacity of three million cubic feet, will be the largest ever constructed. It is estimated that it will rise to a height of more than fifteen miles above sea level.

The first ascent will be made in June by Captain Albert W. Stevens, aerial observer and photographer of the Army Air Corps, who conceived the project, and Major William Kepner, balloon expert. If this flight is successful, a second ascent will be made in September in order to check observations under similar conditions.

The flights will be known as the "National Geographic Society–Army Air Corps Stratosphere Flights." To advise in regard to the scientific plans and equipment, and to direct studies of the data collected, Dr. Gilbert Grosvenor, president of the National Geographic Society, has formed a committee of scientific men. These include:

> Dr. Lyman J. Briggs, *chairman*, director, U. S. Bureau of Standards; Dr. F. V. Coville, botanist, U. S. Department of Agriculture; General Oscar Westover, assistant chief, U. S. Army Air Corps; Captain R. S. Patton, director, U. S. Coast and Geodetic Survey; Dr. W. F. G. Swann, Bartol Research Foundation, Swarthmore College; Dr. Floyd K. Richtmyer, Department of Physics, Cornell University, and member Research Council, American Association for the Advancement of Science; Dr. Charles E. K. Mees, director, Research Laboratory, Eastman Kodak Company; Dr. Charles F. Marvin, chief, U. S. Weather Bureau, and Dr. John Oliver La Gorce, National Geographic Society.

The balloon to be used in the ascents will have a gas capacity five times that of the bag in which Commander Settle established his eleven and a half mile record last November; and nearly three and a half times that of the Soviet balloon which in September rose more than twelve miles above the earth.

The exact point at which the balloon will take to the air has not been selected, but it will probably be in the northern great plains region. Such a choice, it is pointed out, will give ample room for drift to the northeast, east, or southeast and a landing in open country, so that the bag can be salvaged.

In order to house the many instruments and automatic recording devices, the balloon will have attached to it a spherical gondola of light metal nine feet in diameter. Many of the instruments have been designed and modified by Captain Stevens as a result of trials during high altitude flights. They will be largely automatic, leaving observer and pilot free to take care of the many activities in the gondola that will require personal attention. A number of tiny cameras, using motion-picture film, will automatically "read" dials and clock faces simultaneously at frequent intervals.

THE SECOND JOINT EXPEDITION OF YALE UNIVERSITY AND THE WOODS HOLE OCEANOGRAPHIC INSTITUTION

The second oceanographic expedition to the Central American Seas, sponsored jointly by Yale University and the Woods Hole Oceanographic Institution, left Woods Hole on Saturday, January 20, on the research ship *Atlantis*. Professor A. E. Parr, curator of the Bingham Oceanographic Collection of Yale University and research associate at Woods Hole Oceanographic Institution, will be in charge of the scientific work.

The cruise, which is the third in the series of expeditions to these waters begun by the Yale expedition on the *Mabel Taylor* in 1932, will complete the investigations of the previous two cruises by hydrographic observations in the sectors between Jamaica and Central America and between the Caiman Islands and the southern coast of Cuba. Parallel with the completion of the hydrographic sections, the problems of the quantity, nature and origin of the floating Sargasso-weeds and the biology of the animals that live among them will also be taken up for investigation, and a study will be made of the flying fishes.

There are few biological phenomena in the sea of a similar magnitude which have been subject to such entirely contradictory views as have the floating Sargasso-weeds. During the cruise preliminary attempts will be made to apply to floating Sargasso-weeds a method recently developed by marine botanists for inducing the formation of fruit-leaves and causing reproduction of marine algae under experimental conditions. If the treatment should prove effective, it would offer a possibility of settling the question as to origin, although final results are not to be expected during a single short cruise.

By continuous towing of a surface collector of a standard size, the expedition will also attempt to obtain approximate figures for the actual amount of floating weeds present in the areas visited. Heretofore the records of distribution are based chiefly upon such observations as the frequency with which large rafts have been noticed from passing ships, which gives no information as to the actual quantities present in terms of weights or measurements.

C. M. Breder, assistant director of the New York Aquarium, will participate in the cruise, as a research associate of the Bingham Oceanographic Laboratory, to study the habits, development and relationships of the flying fishes. Other participants are M. D. Burkenroad, assistant in the Bingham Oceanographic Laboratory, and M. B. Bishop, assistant in zoology in the Peabody Museum.

AWARD OF THE GOLD MEDAL OF THE AMERICAN INSTITUTE

"For pioneering in industrial research," the General Electric Company was presented on February 1 with a gold medal by the American Institute of the City of New York. The American Institute, which was founded more than a hundred years ago, includes among its objectives the recognition of achievements in science which have profoundly influenced human affairs.

The council on awards of the institute decided that the establishment and maintenance by the General Electric Company of its large laboratory for pure research has been of lasting benefit to human progress and industry. This laboratory, which was created in 1900, when Dr. Willis R. Whitney went to Schenectady from the Massachusetts Institute of Technology to assume the position of research director for the company, has been the scene of scientific discoveries which have greatly expanded existing industries and have created in several notable instances large new industries.

The exercises on February 1 took place at the American Museum of Natural History, where a dinner was served, followed by the presentation speech by the president of the American Institute, Dr. H. H. Sheldon. The medal was accepted by Dr. William D. Coolidge, the present director of the General Electric Company's research laboratory. An hour's program of laboratory demonstrations was then given by members of the laboratory staff.

The text of the citation accompanying the medal is as follows:

> For pioneering in industrial research . . . for great achievements in pure science that have furnished gainful occupation for thousands of workers and that have raised the standard of living and increased health and happiness, the American Institute of the City of New York awards its gold medal to the General Electric Company.

Following the medal presentation a demonstration was given of many of the recent scientific developments made in the laboratories of the General Electric Company, by Ellis L. Manning, a member of the laboratory staff.

The American Institute has not made an award of this sort for many years. The General Electric Company has never before received an award as a corporation, although many of the investigators and engineers working for the company have received awards for individual achievements. The most conspicuous of these was the award to Dr. Irving Langmuir, associate director of the research laboratory, of the Nobel prize in chemistry for 1932. Dr. W. R. Whitney, founder and upbuilder of the laboratory, retired from its directorship in 1931, but retains the title of vice-president in charge of research.

NOMINATION OF OFFICERS FOR THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

The National Nominating Committee of the American Institute of Electrical Engineers, consisting of

members from various parts of the country, has nominated the following official ticket of candidates for the offices becoming vacant on August 1.

For President

J. Allen Johnson, chief electrical engineer, Buffalo, Niagara and Eastern Power Corporation, Buffalo, N. Y.

For Vice-presidents

Northeastern District:
W. H. Timbie, professor of electrical engineering and industrial practise, Massachusetts Institute of Technology.
New York City District:
R. H. Tapscott, vice-president, New York Edison Company, New York.
Great Lakes District:
G. G. Post, vice-president, Milwaukee Electric Railway and Light Company.
Southwest District:
F. J. Meyer, vice-president in charge of operation, Oklahoma Gas and Electric Company, Oklahoma City.
Northwest District:
F. O. McMillan, research professor of electrical engineering, Oregon State College, Corvallis.

For Directors

F. Malcolm Farmer, vice-president and chief engineer, Electrical Testing Laboratories, New York.
Nevin E. Funk, vice-president in charge of engineering, Philadelphia Electric Company, Philadelphia.
H. B. Gear, assistant to the vice-president, Commonwealth Edison Company, Chicago.

For National Treasurer

W. I. Slichter, professor of electrical engineering, Columbia University.

These official candidates, together with any independent nominees that may be proposed later in the manner specified by the constitution and by-laws, will be voted upon by the membership at the coming election in the spring of 1934.

OFFICERS OF THE WASHINGTON ACADEMY OF SCIENCES

THE result of election of the officers for the Washington Academy of Sciences was announced at its annual meeting as follows:

President, L. B. Tuckerman.
Non-resident Vice-presidents, E. C. Andrews, E. T. Wherry.
Corresponding Secretary, Paul E. Howe.
Recording Secretary, Charles Thom.
Treasurer, H. G. Avers.
Members of the Board of Managers for the three year term ending January, 1937, William M. Corse, John E. Graf.
Vice-presidents, representing the various affiliated societies of the academy:
Anthropological Society, Matthew W. Stirling.
Archeological Society, Walter Hough.
Bacteriological Society, N. R. Smith.
Biological Society, Chas. E. Chambliss.
Botanical Society, Charlotte Elliott.
Chemical Society, D. B. Jones.
Engineers, Paul E. Whitney.
Columbia Historical Society, Allen C. Clark.
Electrical Engineers, E. C. Crittenden.
Entomological Society, Harold Morrison.
Geological Society, C. N. Fenner.
Helminthological Society, G. Steiner.
Mechanical Engineers, H. L. Whittemore.
Medical Society, H. C. Macatee.
Military Engineers, C. H. Birdseye.
National Geographic, F. V. Coville.
Philosophical Society, H. L. Dryden.
Radio Engineers, H. G. Dorsey.
Society of Foresters, T. S. Palmer.

THE GEOLOGICAL SOCIETY OF AMERICA

THE forty-sixth annual meeting of The Geological Society of America was held at the University of Chicago on December 28, 29 and 30. More than five hundred persons were in attendance, and a total of more than one hundred scientific papers were presented at the various sessions.

The address of the retiring president, Professor C. K. Leith, on "The Pre-Cambrian," was delivered on the evening of December 28 in Mandel Hall, and was followed by a smoker held in the Reynolds Club. The annual dinner was held at the Shoreland Hotel on the evening of December 29, when the sixth award of the Penrose Medal of The Geological Society, for distinguished service and fundamental contribution to the advancement of geologic science, was announced, the recipient being Professor Waldemar Lindgren, of the Massachusetts Institute of Technology.

The council of the society authorized twenty-six additional research grants at this time, from the income of the bequest to the society under the will of the late Dr. R. A. F. Penrose, Jr. A total of sixty-six grants have now received support from this fund, involving prospective expenditure of $72,000.

The newly elected officers of the society for the year 1934 are:

President, W. H. Collins, Ottawa, Canada.
Past-president, C. K. Leith, Madison, Wisconsin.
Vice-presidents, Arthur L. Day, Washington, D. C.; Eliot Blackwelder, Stanford, California; Percy E. Raymond, Cambridge; John E. Wolff, Pasadena, California.
Secretary, Charles P. Berkey, New York.
Treasurer, Edward B. Mathews, Baltimore.

Councilors, George W. Stose, Washington, D. C.; Raymond C. Moore, Lawrence, Kansas; Joseph T. Singewald, Jr., Baltimore; Frank F. Grout, Minneapolis; W. O. Hotchkiss, Houghton, Michigan; Joseph Stanley-Brown, New York; F. W. De Wolf, Urbana, Illinois; Donald H. McLaughlin, Cambridge; Adolph Knopf, New Haven, Connecticut.

Announcement was made of the election of twenty-one fellows, bringing the total membership to 684.

Meeting with the Geological Society were the Paleontological Society, the Mineralogical Society of America and the Society of Economic Geologists.

The 1934 meeting of the society will be held at the University of Rochester in December, 1934.

SCIENTIFIC NOTES AND NEWS

The Catherine Wolfe Bruce Gold Medal of the Astronomical Society of the Pacific for the year 1934 has been awarded to Dr. Alfred Fowler, professor of astrophysics in the University of London, for "distinguished service in the field of astronomy."

The Colwyn Gold Medal of the British Institution of the Rubber Industry was recently awarded to Dr. O. de Vries, until 1930 director of the Rubber Station, Buitenzorg, for scientific work in connection with the production of raw rubber. The presentation was made by Sir George Beharrell, president of the institution, at the twelfth annual general meeting held on January 12.

Dr. J. Dufrenoy, director of the Station for Plant Pathology, with headquarters at Bordeaux, who has been working for the past year in the laboratory of plant physiology of the Citrus Experiment Station of the University of California at Riverside, has been elected a corresponding member of the Biological Society of Paris.

A special issue of the *American Journal of Pathology* has been dedicated to Dr. Frank Burr Mallory, who recently retired from the professorship of pathology in the Harvard Medical School, in commemoration of his seventieth birthday and of the opening of the Mallory Institute of Pathology of the Boston City Hospital. At a dinner in his honor speeches were made by F. C. Hood, Dr. Elliott C. Cutler, Dr. Hans Zinsser and Dr. James Ewing. Dr. Simeon Burt Wolbach was toastmaster. Dr. Mallory was presented with a complete moving picture outfit and a silver pitcher as tokens of the esteem of his former pupils and his friends on the occasion of his retirement and the dedication of the building.

A testimonial dinner was given to Dr. Stuart McGuire by the faculty and board of visitors of the Medical College of Virginia, at Richmond, on January 15, in recognition and appreciation of his forty years' continuous service to the institution as professor, president and now chairman of the executive committee of the Board of Visitors. Addresses were made by a number of members of the board and faculty, one of them by Dr. J. Fulmer Bright, emeritus professor of anatomy, and now mayor of Richmond.

Dr. Charles O. Townsend, formerly chief of the Sugar Division of the U. S. Tariff Commission, retired from the Federal Service on January 16, after having completed more than ten years in the service of the commission and thirty-two years in the service of the United States Government. At a ceremony attended by his colleagues, Dr. Townsend was presented with a watch. Having reached the age of retirement on January 16, 1933, Dr. Townsend was continued in the service for another year by direction of the President, in order to continue work on which he was then engaged.

The following are the officers of the New York Academy of Sciences for 1934: *President,* Dr. Marshall A. Howe; *Vice-presidents,* Dr. Paul F. Kerr, Nels C. Nelson, Professor Herbert Ruckes and Professor Carl J. Warden; *Recording Secretary,* Dr. Roy Waldo Miner; *Corresponding Secretary,* Professor Horace W. Stunkard; *Treasurer,* Dr. George H. Sherwood; *Librarian,* Dr. G. Kingsley Noble; *Editor,* Mr. Herbert F. Schwarz; *Councilors* (1934–1936), Dr. W. Reid Blair and Dr. Elmer D. Merrill; *Finance Committee,* Harold E. Anthony, Harry C. Raven and John D. Sherman, Jr.

Dr. Milton J. Rosenau, of the Harvard Medical School, was elected president of the Society of American Bacteriologists at the annual session in Philadelphia on December 28. Dr. Karl F. Meyer, of the Hooper Foundation, San Francisco, was named vice-president, and Dr. James M. Sherman, professor of bacteriology and dairy industry at Cornell University, was reelected secretary. Dr. Ludwig Hektoen, who recently retired as chairman of the department of pathology, Division of Biological Sciences, University of Chicago, was elected an honorary member.

Dr. F. W. M. Lamb, lecturer on pathology at the University of Birmingham, has been appointed professor of toxicology and medical jurisprudence on the medical faculty of the University of Cairo. He succeeds Dr. J. Glaister, Jr.

Roland L. Redmond, lawyer of New York City, has been elected president of the American Geographical Society, to succeed Dr. John H. Finley, of the editorial department of *The New York Times,* who has retired after holding office for eight years. Mr. Red-

mond has been a member of the society's council for ten years.

LIEUTENANT-COLONEL ERNEST GOLD has been elected president of the Royal Meteorological Society, London, in succession to Professor Sydney Chapman.

DR. BRADLEY M. PATTEN, associate professor of histology and embryology at Western Reserve University, has resigned to become assistant director for the medical sciences in the Rockefeller Foundation.

DR. CHARLES E. KELLOGG, of the North Dakota Agricultural College, has been promoted to the professorship of soils. Dr. Kellogg has been granted a short leave of absence to assist the Bureau of Chemistry and Soils with some special work in connection with the Soil Survey.

DR. DAVID I. MACHT, formerly lecturer in pharmacology at the Johns Hopkins University School of Medicine, and now director of the Pharmacological Research Laboratory, Hynson, Westcott and Dunning, has been appointed professorial lecturer in general physiology at the Yeshiva College, New York.

DR. JOHN A. HARTWELL, formerly president of the New York Academy of Medicine, has been appointed director to succeed Dr. Linsly R. Williams, who died on January 8. During Dr. Williams' illness and after his death, Dr. Hartwell had been acting as interim director.

DR. ROSS GUNN, research physicist of the Naval Research Laboratory, Washington, D. C., has been promoted to fill the newly established position of technical adviser in the same laboratory.

BURT H. CARROLL, until recently a member of the staff of the Bureau of Standards at Washington, has resigned to become a member of the staff of the Research Laboratory of the Eastman Kodak Company, Rochester, N. Y.

ACCORDING to recent advice from Changsha, Fuliang Chang, for many years a member of the staff of Yale-in-China, has been appointed head of the reconstruction work in the territory recently recaptured from the communists by the nationalists troops in Kiangsi province.

ASSOCIATE editors to serve for three years on *The Journal of Morphology* have been elected by the Wistar Institute as follows: Dr. Charles Zeleny, University of Illinois; Dr. J. F. Daniel, University of California, and Dr. J. S. Nicholas, Yale University.

DR. HARRY BECKMAN, professor and director of the department of pharmacology, Marquette University School of Medicine, Milwaukee, has been appointed American collaborating editor of the Spanish medical journal, *Clínica y Laboratorio,* and will contribute an annual article to the journal.

DR. R. W. CILENTO, Commonwealth health officer in Queensland, has been appointed to the new position of Commonwealth research officer in tropical diseases, with headquarters at the School of Tropical Medicine of the University of Sydney. Dr. Cilento has been engaged in work among the New Guinea natives and has conducted special leprosy surveys in the Western Pacific on behalf of the League of Nations.

THE secretary to the British Minister of Health announces that Professor Sir F. Gowland Hopkins, Professor E. P. P. Cathcart and Professor Edward Mellanby, physiologists representing the Minister's Advisory Committee on Nutrition, will confer with Professor V. H. Mottram, Professor S. J. Cowell and G. P. Crowden, as physiologists representing the British Medical Association Committee on Nutrition, in regard to the differences which appear to exist between the two committees on the question of the amount of calories and first-class protein appropriate as a basis for suitable diets.

LOUIS C. KARPINSKI, professor of mathematics in the University of Michigan, has returned to the United States after spending the first semester abroad on leave of absence, during which he lectured on the history of mathematics at various eastern colleges and universities.

DR. LEONARD A. MAYNARD, of the laboratory of animal nutrition at Cornell University, sailed for China at the end of January. He plans to spend six months, at the invitation of the University of Nanking, assisting in the development of a program of research and education for the improvement of the nutrition of the Chinese farm family.

DR. EDWIN P. HUBBLE, astronomer in the Mt. Wilson Observatory and president of the Astronomical Society of the Pacific, on January 24 delivered an illustrated lecture entitled "The Realm of the Nebulae," before the Sigma Xi Chapter of the University of California at Los Angeles.

ON January 25, Professor William D. Harkins, of the University of Chicago, gave the last of a series of lectures on "Neutrons, and the Photography of the Disintegration of Atomic Nuclei." The series included the Appleton Lecture at Brown University, and lectures at Yale, Princeton and Creighton Universities and the Universities of Iowa, Kansas, Missouri and Pennsylvania, and sections of the American Chemical Society at Wilmington, Chicago, Omaha, Kansas State College, Iowa State College and Kansas City.

PROFESSOR JAMES FRANCK, formerly professor of physics at the University of Göttingen, and James Speyer visiting professor at the Johns Hopkins University, lectured at the Carnegie Institute of Tech-

nology, Pittsburgh, on February 1 and 2. The titles of the lectures were: "Absorption Spectra of Molecules in the Far Ultra-violet"; "Differences of Photochemical Primary Processes in Gases and Liquids," and "Catalytic Processes."

The biennial Huxley Lecture, on recent advances in science in their relation to practical medicine, was delivered by Professor Julian S. Huxley at Charing Cross Hospital Medical School, London, on January 24. His subject was "Embryology as an Experimental Science."

Sir Frederick Gowland Hopkins, president of the Royal Society, formally opened the new chemistry building at the University of Leeds, on January 12, in the presence of the pro-chancellor of the university, Colonel C. H. Tetley, the vice-chancellor, Sir James Baillie, and a representative gathering of past and present members of the university and of visitors from other universities. Sir Frederick Hopkins gave an address entitled "Modes of Thought in Chemistry."

A meeting of the American Section of the Society of Chemical Industry will be held on February 16 at 7:30 P. M. at The Chemists' Club, New York City. The meeting will be devoted to an address by Professor Donald B. Keyes, of the University of Illinois, on "Cooperative Studies on Sulfur Dioxide Removal from Flue Gases." A dinner will be held prior to the meeting at 6 o'clock at the club.

The second annual conference of the Society for the Prevention of Asphyxial Death will open at the Hotel Biltmore, New York City, at 9 o'clock on February 19. Speakers at the conference will include Dr. Chevalier Jackson and Surgeon General Hugh S. Cumming. In the evening of February 20 there will be a dinner to honor the memory of a pioneer in the prevention of asphyxial death, the late Dr. Joseph O'Dwyer. In addition to the presentation of papers, a scientific exhibit and a technical exhibit have been arranged. The technical exhibit will include approved apparatus used in the treatment and prevention of asphyxia. The scientific exhibit will show pathological specimens, both gross and microscopic, charts, models, etc., dealing with the various types of asphyxiation.

A new research project at Battelle Memorial Institute, Columbus, Ohio, has been announced by the director, Dr. H. W. Gillett. This work is being done for the S. S. White Dental Manufacturing Company of Philadelphia, Pa., under the institute's sponsored research plan. The investigation is in charge of Dr. O. E. Harder, assistant director of the institute, and William A. Welcker, research engineer.

It is planned in England by means of scholarships to arrange for the training of Chinese engineering students. Seven students, the first to gain the scholarships awarded by the Federation of British Industries under a grant made from remitted Boxer Indemnity Funds by the Universities China Committee in London, have reached England. The object of the scholarships is to develop trade and cultural relations between China and the United Kingdom. They will have the mutual advantage of acquainting future leaders of Chinese industry with the most modern British engineering standards and methods, and of securing for British industry greater opportunities for business in connection with the industrial development of China. On the completion of their training the students will be helped to secure responsible engineering positions in China. The scholarships have been granted after careful investigation by a committee in Shanghai, and are confined to candidates holding a degree in engineering from an approved university in China or Hong-kong. These students will work with the Metropolitan-Vickers (Electrical Company), Limited, Manchester; Bellis and Morcom, Limited, Birmingham; Sir W. G. Armstrong Whitworth and Co. (Engineers), Limited, Newcastle-upon-Tyne; George Kent, Limited, Luton; Vickers-Armstrong, Limited, Barrow, and Craven Brothers, Manchester. Further scholarships will be awarded during 1934.

Eighteen specimens of meteorites from a group of meteorite craters at Henbury, Australia, have been received at the Field Museum of Natural History, Chicago, and placed on exhibition in the museum's collection. The museum possesses the world's largest meteorite collection as regards the number of falls represented, specimens from more than two thirds of all known meteorite falls being included.

The sum of $1,066,000 from federal funds is assigned at the Virginia Polytechnic Institute for use in building construction and campus equipment under plans recently approved by the Federal Emergency Administration of Public Works. The work includes two dormitories costing, respectively, $300,000 and $200,000, a $370,000 teaching and administration building, a $100,000 utilities building and extension of the water and sewage systems. The administration building is to have an auditorium capable of seating the entire student body.

According to the *Journal* of the American Medical Association, in a recent investigation of the New Jersey state government, conducted by Princeton University, at the direction of Governor Moore, a number of recommendations were made concerning the state health department. To increase the revenue of the department the survey suggested that charges be

made for examinations to test qualifications of persons desiring employment in fields closely connected with public health and for licenses issued to establishments handling foodstuffs. It was recommended that bakeries, canneries and confectioneries be added to the list of such establishments, removing these from the jurisdiction of the department of labor. Other license fees suggested were from individual milk plants from which milk is imported into New Jersey. Regulation of health conditions among persons who work at home for factories was urged as a function of the health department rather than the department of labor; control would be centered in a bureau of homework industries, the cost of which would be distributed among the contractors distributing such work. Among internal changes recommended were restoration of the publication of *Public Health News*, the department's bulletin; combination of the bureau of venereal diseases with the bureau of local health administration, which handles problems concerned with other communicable diseases; restoration of appropriations to provide offices and help for district health officers, and abolishment of the health officer of the port of Perth Amboy.

DISCUSSION

NOMENCLATURE FOR THE ISOTOPES OF HYDROGEN (PROTO- AND DEUTO-HYDROGEN) AND THEIR COMPOUNDS

IN this letter it is proposed that the nomenclature suggested by Urey, Brickwedde and Murphy[1] for the isotopes of hydrogen should not be abandoned, as recently suggested by Rutherford,[2] but modified in such a way as to make it more general. The necessity for such a modification arises when it is desired to name what they refer to as "the nine varieties of water."

The fundamental difficulty of their nomenclature is that it specifies an atomic species by a single name, while by any simple numerical system two independent variables are involved. These may be the atomic number and atomic mass, but in a general system it is much more simple, and less confusing in the end, to use the atomic number and the isotopic number. If P is the whole number closest to the atomic mass, then the isotopic number (I) is given by the relation

$$I = P - 2Z \qquad (1)$$

in which Z is the atomic number. Since as many as 91 elements are now known, and some of these have as many as 11 isotopes, it is obvious that any system which gives an individual name to each isotope, without any reference to the element to which it belongs, can not fail to be confusing. The simplest system is, obviously, one in which numbers alone are used. The use of the isotopic number rather than the atomic mass has several marked advantages. Thus the isotopic numbers are much smaller than the masses, they exhibit the relations between atomic species much more simply, and also the isotopic number of the most abundant isotope of a light element of even number is zero, while that for an element of odd number is one. Only in the exceptional case of the proton is this minus one instead of plus one.

On account of the predilection of human beings for names, rather than numbers, it is perhaps entirely visionary to expect the general adoption of the more logical numerical system, so the discussion which follows presents a few of the numerical designations, and the names which may be supposed to represent them.

Hydrogen of atomic weight 1 is represented by (1, –1), or more simply by 1–1, in which 1 is the atomic and –1 the isotopic number. Since H designates atomic number 1, this may be written $H^{\bar{1}}$ (to represent H^{-1}). In accord with recently suggested usage this is protium, but a more general system of designation is introduced if this is changed to protohydrogen.

The names for the isotopes of hydrogen become *protohydrogen, deutohydrogen* and *tritohydrogen*, though it is not certain that the last has been discovered. It is possible that *deuterohydrogen*, which is somewhat more correct, but longer, may be preferred for the second of these.

Hydrogen of atomic weight 2 is represented by (1, 0), or by H^o, or deutohydrogen.

Heavy water with light oxygen is $(1, 0)_2(8, 0)$, or in more ordinary symbols $H^o{}_2O^o$, and may be named dideutohydrogen-oxide^o, in which ^{o} represents that the oxide contains the zero isotope of oxygen. While this is a slightly mixed system of nomenclature, it seems preferable to that given by the logical extension of the recently suggested system of naming, which gives dideuterium-hekaidekatium. Also protodeuto-hydrogen oxide[1] is, according to this extension of the present system, protium-deuterium-heptakaidekatium. However, a greater difficulty arises in the present system in that dideuterium-hekakaidekatium represents not only $H^o{}_2O^o$, but it also represents the group $-N^2H_2{}^o$, which contains the recently discovered isotope of nitrogen, isobaric with the zero isotope of oxygen. Thus this system is incapable of distinguishing between isobars.

The compounds

[1] SCIENCE, 78: 602, 1933.
[2] *Nature*, December 23, 1933.

$$H^1\overline{H}^0, \quad NH^1\overline{H}^0, \quad NH^1_2\overline{H}^0, \quad C_6H^1_2\overline{H}^0_4$$

may be designated as proto-deuto-hydrogen, dideuto-ammonia, monodeuto-ammonia and tetradeuto-benzene. Since at present we do not say hydro-benzene, or hydro-ammonia, it is unnecessary to introduce the word hydrogen.

Table 1 gives the formuals of a few isotopic molecules. Those in which the isotopic numbers are used are seen to be much more simple than those with the atomic mass.

TABLE 1

ILLUSTRATIVE FORMULAS FOR MOLECULAR ISOTOPES. I. WITH SYMBOL AND ATOMIC MASS. II. WITH SYMBOL AND ISOTOPIC NUMBER.

I	II
Sulphur Dioxide (18 Molecular Isotopes.)	
$S^{32}O^{16}_2$	$S^0O^0_2$
$S^{33}O^{17}O^{18}$	$S^1O^1O^2$
Carbon Dioxide (12 Molecular Isotopes.)	
$C^{12}O^{16}_2$	$C^0O^0_2$
$C^{13}O^{17}O^{18}$	$C^1O^1O^2$
Carbon Tetrachloride (10 Molecular Isotopes.)	
$C^{12}Cl^{35}_3Cl^{37}$	$C^0Cl^1_3Cl^3$
Tin Tetrachloride (55 Molecular Isotopes.)	
$Sn^{112}Cl^{35}_2Cl^{37}_2$	$Sn^{12}Cl^1_2Cl^3_2$
$Sn^{120}Cl^{35}_3Cl^{37}$	$Sn^{20}Cl^1_3Cl^3$
Benzene (49 Molecular Isotopes: also many isomers.)	
$C^{12}_4C^{13}_2H^1_3H^2_3$	$C^0_4C^{\bar{1}}_2H^1_3H^0_3$

On the whole, it seems that no system of naming the atomic species can be at the same time logical and simple, if numbers are not utilized. In conclusion, it may be reaffirmed that the two best systems aside from those wholly numerical are the use of the (1) symbol of the element plus the atomic mass, (2) symbol of the element plus the isotopic number.

The second is much simpler than the first, and should be adopted. Its only disadvantage is the extremely slight mental effort necessary to comprehend the significance of the isotopic number. While equation (1) gives the best definition of this quantity, it may be noted that the formula for any atomic nucleus may be written $(np)_Z n_I$, in which n represents a neutron and p, a proton, and I gives the number of the isotope. Since for a proton Z is unity, the value of I must be minus one. For any other known nucleus I is always zero, or a positive number from 1 to 54. For most of the individual atoms on earth, or in the meteorites, the value of I is zero. Professor Mulliken has prepared a detailed system of nomenclature for the compounds of hydrogen, which is, on the whole, in agreement with what is suggested in this communication.

The argument has been advanced that each radioactive atomic species has an independent name which does not express the name of the element. Thus Ra^{48} is designated as thorium X, Ra^{50} as radium and Ra^{52} as mesothorium 1. However, the names indicate that thorium X is the X disintegration product from thorium, mesothorium 1 is the first descendent from thorium, etc. That is, the names give the family or series to which the atomic species belongs, which is of primary importance in the study of radioactivity. Since the name deuterium, suggested for the zero isotope of hydrogen, does not indicate that it is a member of the uranium series, such a justification for an independent name has no basis. Thus *deutohydrogen,* or *deuterohydrogen,* is in much better accord with a simple system of designation for the atomic species in general. The term deuton is already in general use for the nucleus of an atom of deutohydrogen, while a proton is the nucleus of an atom of protohydrogen.

Publications received within the last few days indicate that Rutherford's suggestion of the use of the term "diplogen" or double, for deutohydrogen, is being adopted rapidly in England. This term is not suitable for use in chemistry unless a name is also given for $H^{\bar{1}}$, that is for hydrogen of mass 1, which, according to this should be called haplogen, or preferably ***haplohydrogen.*** The adoption of this system changes the designation of the nucleus of the atom of heavy hydrogen from *deuton* to *diplon.* This system of nomenclature seems as satisfactory, but not more so, than that of Urey, except that it has the disadvantage that it changes the name of the *proton* to ***haplon.*** It is, of course, possible that an etymologically mixed system may be adopted, such as protohydrogen and diplohydrogen for the atoms, and proton and diplon for their nuclei.

The organic chemist is particularly interested in the nomenclature, since even with only two isotopes of hydrogen and two of carbon, several thousand varieties of a single organic compound can be formed. Even very simple compounds, such as benzene may have several hundred forms. Thus $C^1_4C^0_2H^0_3H^1$ which is only one of the 49 isotopes of benzene, has nine isomers. For large molecules which contain, C, H, O, S, and N, the number of forms may be of the order of a hundred thousand (10^5).

The system which uses the atomic and isotopic numbers to indicate atomic species, needs no extension to include both the negative electron and the positive electron (negatron and positron). Thus the negative electron is $(-1, 2)$, which, by a change of

signs becomes $(1, -2)$, which is the positive electron. The neutron is $(0, 1)$, since the general formula for any nucleus is $(np)_z\ n_I$ or $H^0_z\ n_I$ in which n is a neutron, and the atomic number Z for the neutron is zero.

WILLIAM D. HARKINS
UNIVERSITY OF CHICAGO

ISOTOPIC NOMENCLATURE

THERE has been an increasing amount of discussion relative to suitable words and symbols for the designation of isotopes. Already the words "protinium" and "deuterium" have been used to denote the hydrogen isotopes of mass 1 and 2, respectively. Also the formula of ammonium containing one atom of hydrogen of mass 2 has been written NH_2D and $NH_2\overline{H}$.

At present experimental evidence points to the fact that many of the elements are composed of at least three isotopes. Furthermore, it appears to be only a matter of time before many of the isotopes will be prepared in a pure state and in sufficient quantity to examine their properties. In the meantime, however, considerable confusion may arise, assigning to isotopes symbols and names which are not only at variance with common usage but will also tend to create an elaborate nomenclature.

Two examples should serve to make this point clear. There are at present at least 80 isotopes known. First, if each of these isotopes is assigned a name unassociated with its element the memory of the average chemist will be greatly taxed. Second, if we assign a numerically derived name, such as "protinium" or "deuterium," we might call an isotope of mass 86 hakloskyhogdoekostium (ἐκτος καὶ ὀγδοηκοστός) and yet be uncertain, unless the context supplied the information as to whether isotope of mass 86 of strontium or krypton was meant, for both have an isotope of this mass.

It would seem to the writer to be more advantageous for the present to run the risk of being verbose but exact and designate an isotope as follows: Hydrogen of mass 2, or oxygen of mass 17, and use the simple words hydrogen, oxygen, strontium, etc., to designate the usual isotopic mixture found of the element in question. If the amounts of the isotopes have been varied to a marked degree, then write out the percentages of the various isotopes present.

In chemical formulas the use of the symbol of the element together with the suitable number or numbers in exponential position, and with the use of structural formulas to clarify isomeric relationships would still appear advisable, rather than injecting new symbols or signs just at present.

And last but not least it is recommended that a suitable international committee be appointed which would rule upon changes in nomenclature, should the occasion arise, and thereby avoid getting into a confused nomenclature such as the one in organic chemistry, from which we are now being rescued by the Commission on the Reform of the Nomenclature of Organic Chemistry.

J. B. FICKLEN
HARTFORD, CONN.

REACTION TO MOSQUITO BITES FOLLOWING TREATMENT FOR COLD IN HEAD

FOR some years past the writer has been raising mosquitoes for experimental purposes. These have been fed on the forearm, and no ill effects have been observed. There has been practically no swelling or discomfort, and within a very few minutes the slight redness at the site of the puncture disappeared. Recently the writer contracted a severe cold in the head, and on advice, took alkaline salts as a treatment. A teaspoonful of Citro Carbonate of Magnesia was taken every hour for several hours, so that the urine gave an alkaline reaction on litmus paper. At this time the mosquitoes were fed as usual, and within ten minutes, at the site of every puncture, appeared a white swelling, six to ten millimeters in diameter, surrounded by a red aureole and accompanied by an almost intolerable itching. These swellings lasted for about half an hour and gradually disappeared. During the time the system was alkalized, each feeding was followed by the appearance of these swellings, accompanied by intense discomfort. At the time of writing, three weeks after the last dose of Citro Carbonate of Magnesia, the mosquitoes are still being fed, but once more without the occurrence of swellings, discoloration or itching. The mosquitoes, *Aedes egypti*, emerged in December, and the same individuals were used during the whole time covered by these observations. The writer is curious as to the connection between this treatment for cold and the reaction to the mosquito bites which followed.

G. ALLEN MAIL
MONTANA AGRICULTURAL EXPERIMENT STATION
BOZEMAN

MORTALITY AMONG TROPICAL FISH

A HIGH infant and adult mortality rate among different varieties of tropical fish was completely checked by the addition of viosterol to a diet already containing desiccated shrimp, beetle and ground fresh liver. Deeper pigmentation and increased activity were noted. Several fish whose vertebral columns had softened and deformed recovered their rigidity after addition of the viosterol. However, the deformity persisted.

The viosterol and its oily medium were mixed with

the desiccated food and the mixture placed in a feeding ring. The portion that the fish failed to eat in a short time was removed.

Dr. Sidney Brown initiated the use of this food. In the absence of any controlled test I can only remark on the interest of this information.

J. I. Spira

Chicago, Ill.

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE WORK OF THE PRESS

So far as the press is concerned, the meetings of the association are centered in the press room. The press representatives can find in the press room sufficient material available for their use so that there is no necessity for them to listen to the reading of any of the papers or addresses. Furthermore, a much better, more adequate and more accurate account of an address or paper can be prepared from the manuscript than from notes taken while it is being read. Therefore, unless a copy of a paper or address is in the press room, that paper or address in all probability will receive no notice in the press.

This year an unusually small proportion—scarcely more than one fifth—of the papers read were sent in advance to the Press Service. There were 1,540 papers (including exhibits, demonstrations, etc.) listed in the program, of which 325 (21 per cent.) by 303 different authors were received in advance.

If the 74 papers that were not received until after the meeting (partly because of having been mailed with insufficient postage) are added to the number sent in, and the 113 mathematical papers, which can not be handled successfully in the usual routine, be subtracted from the total number of papers listed, there were 1,427 papers presented, of which 399 (28 per cent.) were sent in.

The number of papers listed and received, arranged by groups, were as follows:

Section or Group	Papers Listed	Papers Received
Exhibits and Demonstrations	18	5
General Sessions and Committees		6
Joint Sessions	96	21
Mathematics (A)	113	0
Physics (B)	94	17
Chemistry (C)	7	3
Astronomy (D)	28	7
Geology and Geography (E)	16	12
Zoological Sciences (F)	436	60
Botanical Sciences (G)	227	82
Zoology and Botany (F and G)	100	19
Anthropology (H)	32	11
Psychology (I)	38	16
Social and Economic Sciences (K)	23	2
Historical and Philological Sciences (L)	15	6
Engineering (M)	21	5
Medical Sciences (N)	19	5
Agriculture (O)	195	23
Education (Q)	39	19
Science in general (X)	23	6
Totals	1,540	325

In addition to the typewritten manuscripts and abstracts listed above, many excellent printed abstracts were sent in. But for press use printed abstracts are by no means so good as typewritten abstracts. They convey the impression that the material has already been published, or may have received press notice; they can not be distributed with the others in the official blue covers, without which abstracts and manuscripts are regarded with more or less suspicion; and many of the press representatives, especially the representatives of the local papers, will not take the trouble to read them. If copies of the manuscripts of the printed abstracts were sent to the Press Service it would help greatly in securing adequate notice of the papers.

Abstracts are of much less value for press use than complete papers, because as a rule they do not provide sufficient background for a press story. Unless the press representative who reads the average abstract happens to be more or less familiar with the subject-matter the abstract is not of much interest to him. But abstracts are very useful in presenting briefly the main points of interest in a paper.

Unfortunately, only single copies of many of the papers and abstracts were received this year. Two copies of each are desired in order that up to the time of the meeting one may be retained in the press room at Washington and the other sent to the city in which the meeting is to be held. Press representatives in both cities therefore have an opportunity of studying the material in advance of the meeting. During the meeting both copies are in use in the press room.

It is, of course, impossible to notice in the press all the papers given during a meeting, or even any large proportion of them. After the meeting all the papers are gone over with great care, and news items prepared from them appear throughout the year under the date line of the city in which the work was done. Some of them are also used as material for feature articles.

Papers sent to the Press Service are for press use only. They are not returned after the meetings. Every effort is made to see that they are given due consideration by the press representatives. They are regarded as confidential, and no one other than the press representatives is allowed to see them.

The Press Service does not prepare abstracts or

transcripts of the papers sent in, but simply passes them on to the press writers for their inspection. These gentlemen do all the writing, and the selection of the material to be written up, as well as the method of presenting it, is left entirely in their hands. The Press Service regards them as competent experts in their line, just as the authors of the papers are in theirs.

The quality of the material received this year was excellent, so good, in fact, that this more than made up for the somewhat limited quantity. For some time there has been noticed each year an improvement over the year preceding in the form in which the manuscripts are prepared, and this year the improvement was especially noteworthy.

The Press Service is deeply appreciative of the cordial cooperation received from the secretaries of the sections and societies and the members of the association on the one hand, and the representatives of the press on the other. Any comments or suggestions made are not to be taken as implying any criticism or lack of appreciation. They are made with the object of bringing us ever nearer that elusive goal, perfection.

AUSTIN H. CLARK,
Director

SCIENTIFIC APPARATUS AND LABORATORY METHODS

PREPARING AND STENCILING TOPOGEOLOGIC MODELS

FOR laboratory study in college courses in geology it is desirable to have at least one model for four students. In large classes this means a large expenditure for equipment and consequently the least possible cost for models. Economy may be effected by quantity production at the place of demand, especially if the institution has a museum staff especially trained to do the work. Geologic models equal in area to the size of quadrangle maps published by the United States Geological Survey are commonly useful and may be prepared in the following manner at minimum cost.

Beginning with the lowest, each contour on the map selected is traced onto a separate cardboard which is of suitable thickness to give the desired result of relief exaggeration. The pantograph may be used to vary the size of the model. The areas enclosed by contours are cut out with scissors, a jig saw or an appliqué machine. The pieces representing successively higher levels are nailed one on top of the other until the relief is shown in a series of irregular steps. Accurate vertical registration may be obtained by having each original cardboard squared up with the edges of the map; this may be used as a guide if the cut contour area is held in place on the card until it has been nailed onto the growing model. The waste may then be pulled away. Registration may also be insured by setting up dowels on the base to which the contour cards are nailed. On the map circles corresponding to the positions of the dowels allow one to trace their position and cut them out on each contour card, which is slipped onto the dowels and nailed in position.

When the construction of the topography is completed, plasteline is applied to smooth off the steplike structures caused by the cardboard. A frame to form a well is fitted around the model. Petrolatum is applied to the surface of the model and inside the frame. A mixture of plaster of Paris and water is poured into the frame and a soft brush is plunged into it and drawn back and forth on the surface of the model before the plaster sets; this releases air bubbles and eliminates patching of the negative or model. Jarring the model is also effective.

After the mold has become thoroughly dry, which sometimes takes several days, it must be given two or three coats of thin shellac. The mold may then be utilized to make as many casts as are desired in plaster, wax or papier-maché. Plaster casts are the most economical and may be reinforced with quarter-inch wire mesh, which is sunk into the plaster before it sets. The mold must be greased each time a cast is made. When dry the casts are shellacked.

In preparation for the stencil, which facilitates the painting of the geological pattern, an extra mold and cast are made, being careful to have the sides of the mold vertical to the edges of the map. Vertical registration of the sides will be automatically accomplished if a wooden frame is fitted to the original model and used for all casting.

The geological pattern is drawn on tracing paper, which is laid over the map. The tracing paper is then fastened to the bottom of the mold and with a sharp knife blade the pattern is cut through and scratched onto the smooth surface of the bottom of the mold. The pattern is then gone over with a lead pencil to make it distinct. During this and the following process the mold rests on the cast. All the casting must be done on a smooth level surface such as slate, in order to insure accurate vertical registration of the geological pattern when it is cut through the mold.

The mold and cast are then placed on the cutting table of a jig saw and the pattern is cut into pieces corresponding to a puzzle. The pieces of the cast are thrown away and a new cast is made to act as a support for the mold pieces when they are not being

used. The pieces should be thoroughly shellacked. Any parts of the geological pattern may be painted on a fresh cast with the air-brush. This is done by protecting the surrounding parts of the cast with the pieces of the stencil. After a single color has been applied to several casts, and has become dry, other colors may be blown on in succession until the whole geological pattern has been applied to the casts. Lakes and major streams may be blown on with the air-brush through a sheet lead stencil which has been drawn down to fit the topography. Complicated stream patterns and printing require hand work.

EDWARD J. FOYLES

UNIVERSITY OF ROCHESTER

A METHOD FOR CONCENTRATING AND FIXING FREE-LIVING PROTOZOA ON COVER GLASSES

IN making slides of free-living protozoa the greatest difficulty usually encountered is the sticking of large numbers of organisms on the slide or cover glass, as the case may be. This difficulty is greatly overcome by the following method for fixing on the cover glass. By folding paper with a porousness comparable to that of mimeographing paper, make a box about 20 mm deep and of a size into which the cover glass closely fits. Smear the cover glass thinly with egg albumen and place it face up into the box. Stand the box on blotting paper and fill it with fixative to a depth of 4 mm, or more if the cultures are poorly populated. Into the fixative pipette an equal, or less, amount of water containing the protozoa. The fluid seeps out and is absorbed by the blotting paper. Because the seepage is uniform and relatively slow, the organisms are left securely fastened and evenly distributed on the cover glass. When only a thin film of the fluid still envelops the organisms, remove the cover glass and drop it face down into a dish of the fixative. After fixation, follow the usual procedure for the fixing solution and stain selected. Reverse the above process, when fixing rhizopods, by putting them into the box, allowing them to become attached and then adding the fixative.

The various fixing solutions and stains give good results with the above method. Navaschin's solution is particularly good for sticking the organisms on the cover glass. Since the crystal violet-iodine staining method leaves the cytoplasm almost colorless, yet stains the nucleus well, it is excellent for studying nuclear divisions in total mounts of protozoa. With this stain and the above method for fixing, the nuclear behavior in ex-conjugants of *Paramecium caudatum* is easily followed; the chromosomes are especially sharply defined.

J. T. BALDWIN, JR.

THE BLANDY EXPERIMENTAL FARM AND
THE MILLER SCHOOL OF BIOLOGY
UNIVERSITY OF VIRGINIA

SPECIAL ARTICLES

THE INCIDENCE OF THE DISEASE-PRODUCING AMOEBA (ENDAMOEBA HISTOLYTICA) IN 1060 COLLEGE FRESHMEN AND ITS SIGNIFICANCE

DURING November, 1933, the newspapers of the country carried items concerning an "outbreak" of amoebic disease in Chicago, with reports of 100 or more cases and a number of deaths. These reports gave the impression that the disease-producing amoeba (*Endamoeba histolytica*) is extremely rare and mostly confined to the tropics.

While it is true that amoebic disease is more prevalent in the tropics and that the incidence of the parasite tends to become lower in the more temperate regions, nevertheless, it has been amply demonstrated that this amoeba is world-wide in its distribution and is not uncommon in the more temperate climates. In fact, the first case of amoebic dysentery to be reported in the literature, by Lösch in 1875, was found in a northern locality, St. Petersburg (now Leningrad), Russia. Since then the disease and the parasite have been extensively studied in many parts of the world.

Craig[1] has called attention to the probability that between 5 per cent. and 10 per cent. of the population of the United States harbor *Endamoeba histolytica,* while, in our more southern states, Faust,[2] Meleney[3, 4] and others have found a still higher incidence of infection. In order to determine the incidence of *E. histolytica* and other intestinal Protozoa in college students, the present authors added an examination of a single ordinary stool to the regular medical ex-

[1] C. F. Craig, "The Amoebiasis Problem," *Jour. Am. Med. Assoc.*, xcviii: 1615–1620, 1932; "The Pathology of Amoebiasis in Carriers," *Am. Jour. Trop. Med.*, xii: 285–299, 1932.

[2] E. C. Faust, "A Study of the Intestinal Protozoa of a Representative Sampling of the Population of Wise County, S. W. Virginia," *Am. Jour. Hyg.*, xi: 371–384, 1930; "The Incidence and Significance of Infestation with *Endamoeba histolytica* in New Orleans and the American Tropics," *Am. Jour. Trop. Med.*, xi: 231–237, 1931.

[3] H. E. Meleney, "Community Surveys for *Endamoeba histolytica* and Other Intestinal Protozoa in Tennessee," *Jour. Parasitol.*, xvi: 146–153, 1930; H. E. Meleney, E. L. Bishop and W. S. Leathers, "Investigations of *Endamoeba histolytica* and Other Intestinal Protozoa in Tennessee." "III. A State-wide Survey of the Intestinal Protozoa of Man," *Am. Jour. Hyg.*, xvi: 523–539, 1932.

aminations of incoming students at a professional school in Philadelphia. In the fall of 1931, 401 freshmen were examined, and the results have been published.[5] Since then, 299 and 360 were added in 1932 and 1933, respectively, making a grand total of 1,060, of whom 351 were women and 709 were men.

From the examination of a single stool per person, it was found that 2.3 per cent. of the women and 4.9 per cent. of the men, or 4.1 per cent. of the total, harbored *E. histolytica.* It has long been held that a single examination of a group of individuals reveals only from 30 per cent. to 40 per cent. of the actual incidence of this amoeba. It is, therefore, safe to estimate that our incidence of 4.1 per cent. based upon one examination probably indicates a true incidence of as much as 10 per cent.

Over 90 per cent. of these 1,060 students came from homes in Pennsylvania or New Jersey, and few had traveled extensively either in the United States or abroad. Hence it is probable that these students became infected before coming to college, so that the incidence found indicates the presence of the parasite in these districts.

It should, of course, be emphasized that most of the students harboring *E. histolytica* were "carriers," as are most of those who harbor this amoeba in temperate climates. The "carrier" shows no symptoms of disease, but discharges cysts which are the infective stages, capable of infecting other persons, some of whom might succumb to the disease. In rural districts and other places where sewage disposal facilities are inadequate, it is known that flies are effective agents in the dissemination of such cysts. In the cities, food-handlers in public eating places who are carriers, and who may be careless or uncleanly in their personal habits, are the most probable sources of infection. Just why some persons when infected by this amoeba become ill, while others do not, is not exactly known. It seems probable, however, that some individuals have a greater natural resistance to this parasite than others and also that some strains of the parasite may be more virulent than others.

Our data support Craig's belief that between 5 per cent. and 10 per cent. of our population harbor the disease-producing amoeba and, if this is true, it is not surprising that a number of people contracted the disease in Chicago this past summer. It may also be seriously questioned whether or not the incidence of amoebic disease was so different from that at other times and in other large centers of population. Since amoebic dysentery is considered to be so rare by many medical men, the true nature of such cases is likely to be overlooked. Amoebic disease is admittedly difficult to differentiate from other disturbances of the digestive tract and normally requires the finding of the amoebae themselves in the feces or in the tissues obtained at autopsy. With four other amoebae resident in the human bowel, proper diagnosis requires special training in the technique of examination and in the differentiation of these different types of parasites. It may be significant that recognition of the disease in Chicago apparently came at the end of the summer, when deaths occurred and autopsies revealed the nature of the disease in its true light.

In consideration of the above statements, it may be suggested that: (1) The general public, as well as medical men, should be made aware of the wide-spread distribution of *Endamoeba histolytica* and should appreciate the methods by which this potentially pathogenic parasite is disseminated. (2) Public health officials might well arrange for adequate examination of the food-handlers in public eating places to detect carriers among them, positive cases being treated to eliminate the parasite. (3) Many diarrheas, dysenteries and other disturbances of the digestive tract are due to causes other than the presence of amoebae; hence a diagnosis of amoebic disease is scarcely justified unless *Endamoeba histolytica* be found in the stools or detected in material obtained with the proctoscope or in pathological tissues. (4) In view of the fact that four other kinds of amoebae occur in the large intestine of man, two of them with greater frequency than *E. histolytica,* it should be especially emphasized that special training is required before one can hope to recognize the different types and distinguish *E. histolytica* from the others.

D. H. WENRICH
R. M. STABLER
J. H. ARNETT

UNIVERSITY OF PENNSYLVANIA

[5] J. H. Arnett, D. H. Wenrich and R. M. Stabler, "A Survey of 401 College Freshmen for Intestinal Protozoa," *Am. Jour. Trop. Med.*, xiii: 311–315, 1933.

BOOKS RECEIVED

BLISS, GILBERT A. *Algebraic Functions.* Pp. ix + 219. American Mathematical Society, New York.

DWIGHT, HERBERT B. *Tables of Integrals and Other Mathematical Data.* Pp. viii + 222. Macmillan. $1.50.

FISCHER, MARTIN H. and MARIAN O. HOOKER. *The Lyophilic Colloids.* Pp. viii + 246. 84 figures. Charles C. Thomas. $4.50.

FURBAY, JOHN H. *Nature Chats: A Year Out-of-Doors.* Pp. xiv + 255. Illustrated. Distributed by The Science Press Printing Company. $1.75.

HALL, RALPH C. *Post-Logging Decadence in Northern Hardwoods.* Pp. 66. 27 figures. University of Michigan Press.

KOFOID, CHARLES A., Editor-in-Chief. *Termites and Termite Control.* Pp. xxv + 734. 182 figures. University of California Press. $5.00.

KOVÁCS, RICHARD. *Nature, M.D.* Pp. vi + 181. Illustrated. Appleton-Century. $2.00.

SHARP, LESTER W. *Introduction to Cytology.* Third edition. Pp. xiv + 567. 230 figures. McGraw-Hill. $5.00.